A Researcher's Perspective on Function Allocation and its Application to Air Traffic Management

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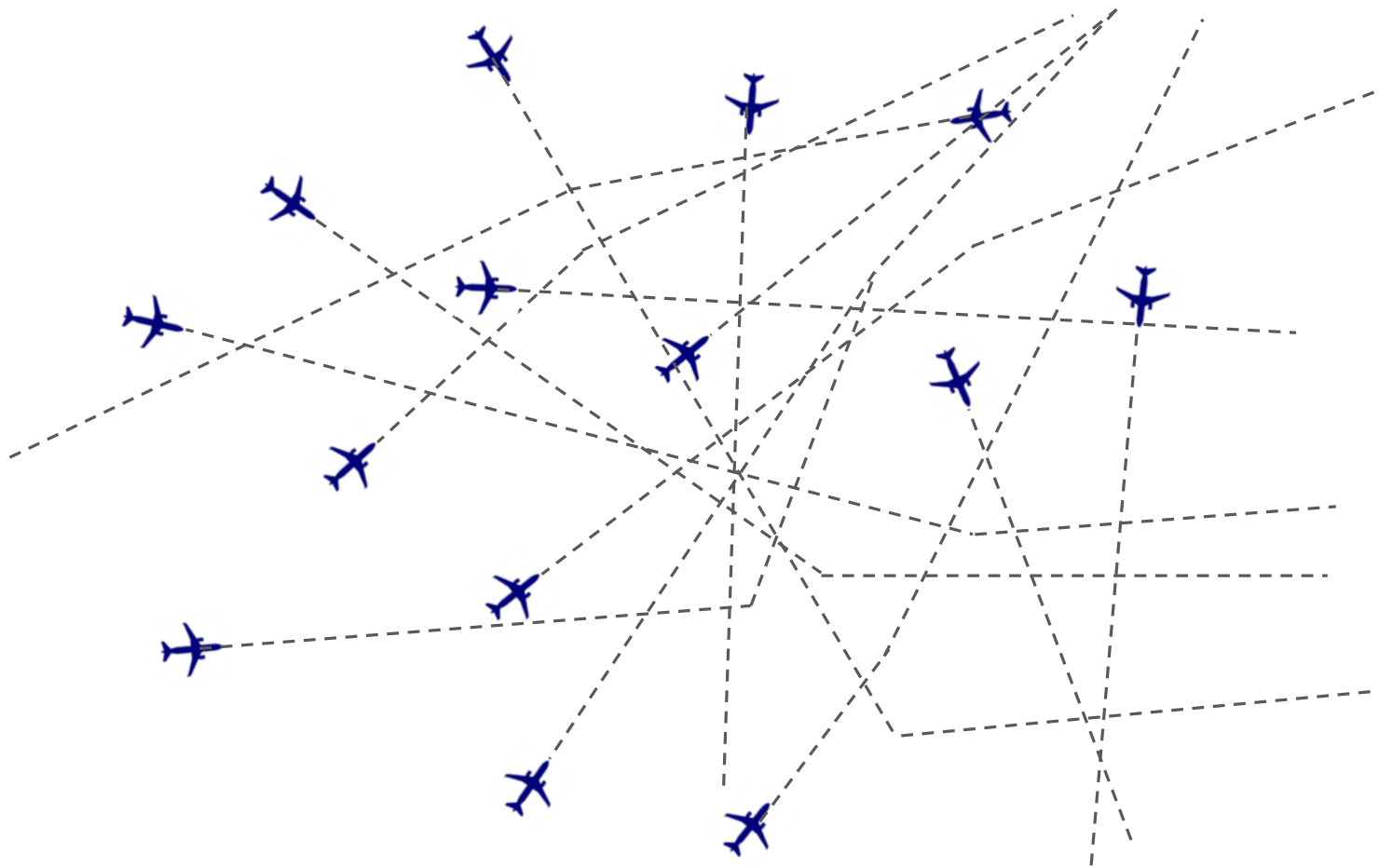
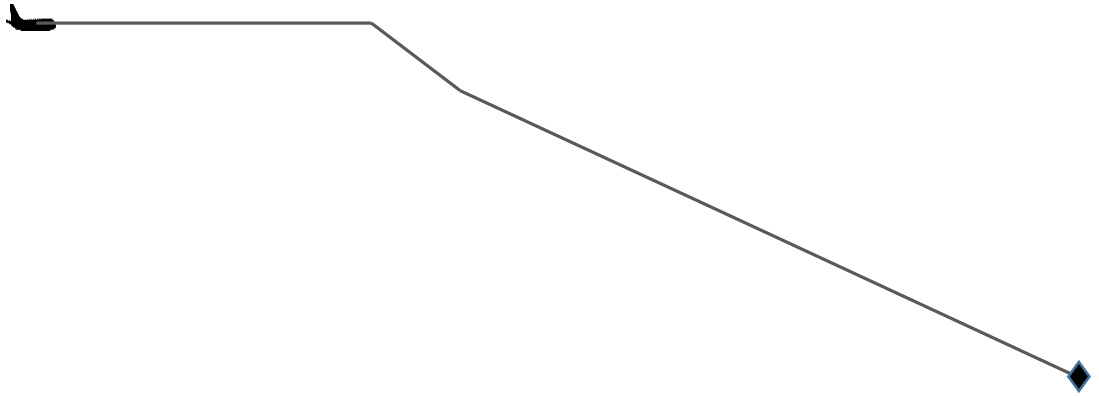
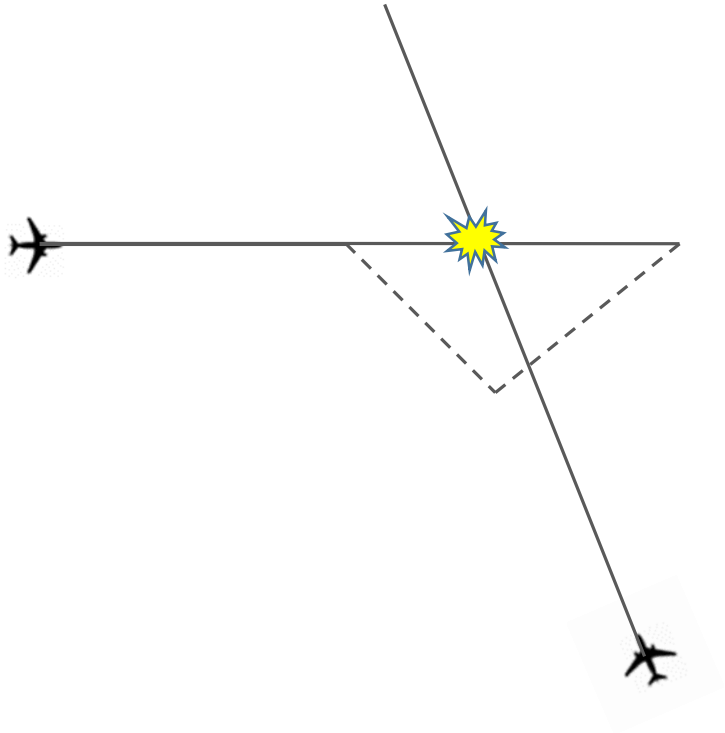
NASA



Past Research Focus

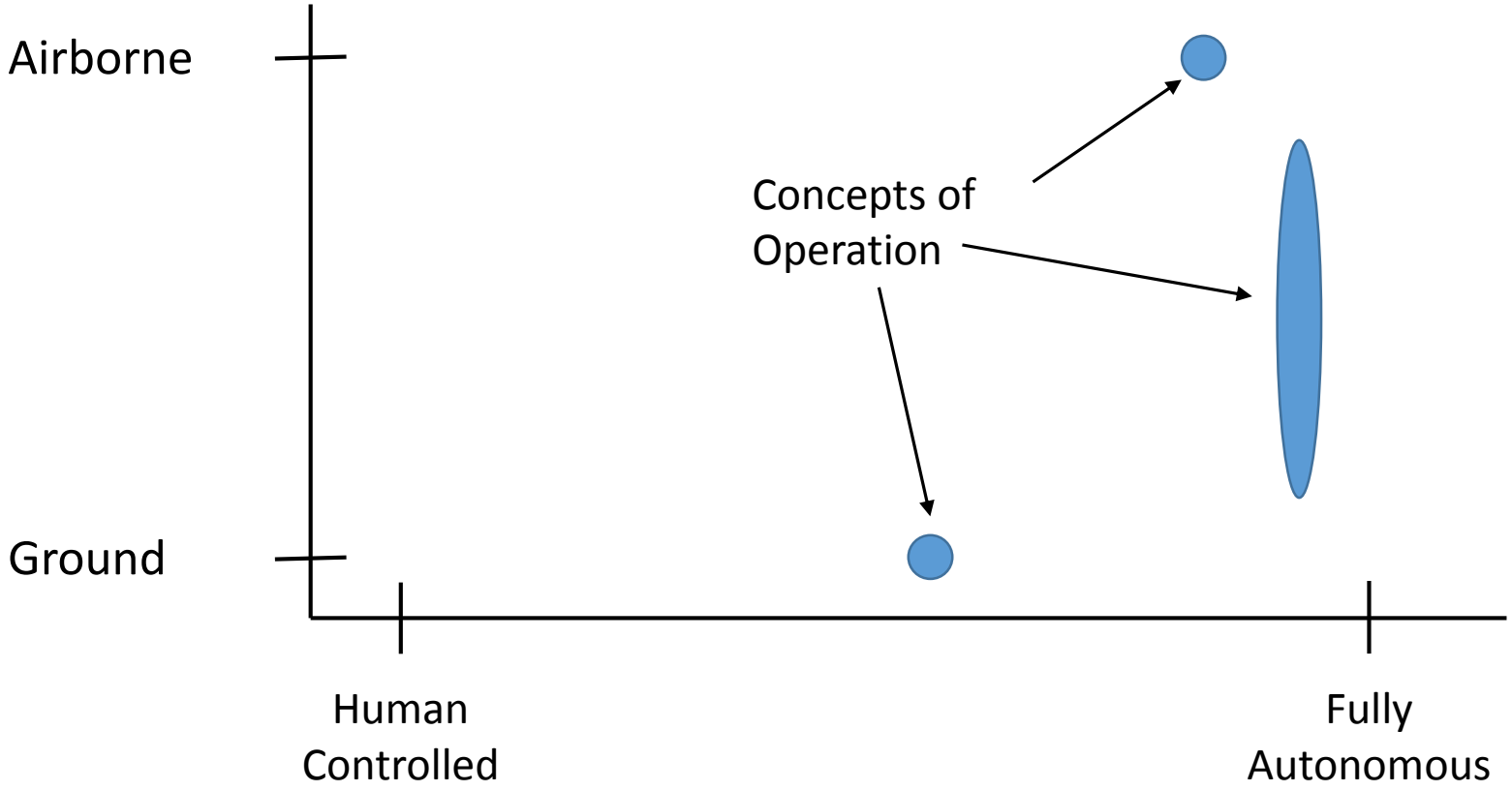


Technologies

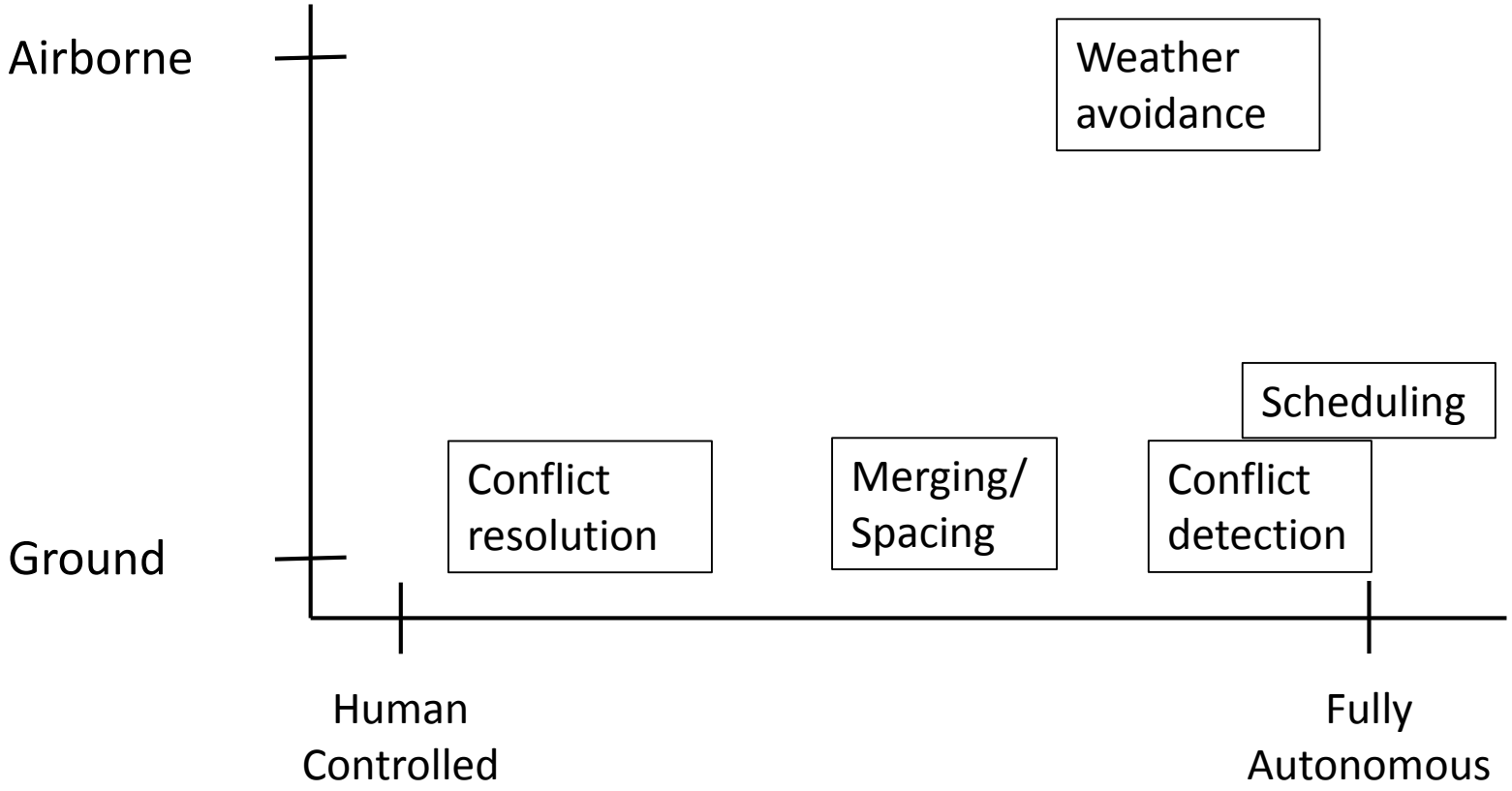


Algorithms

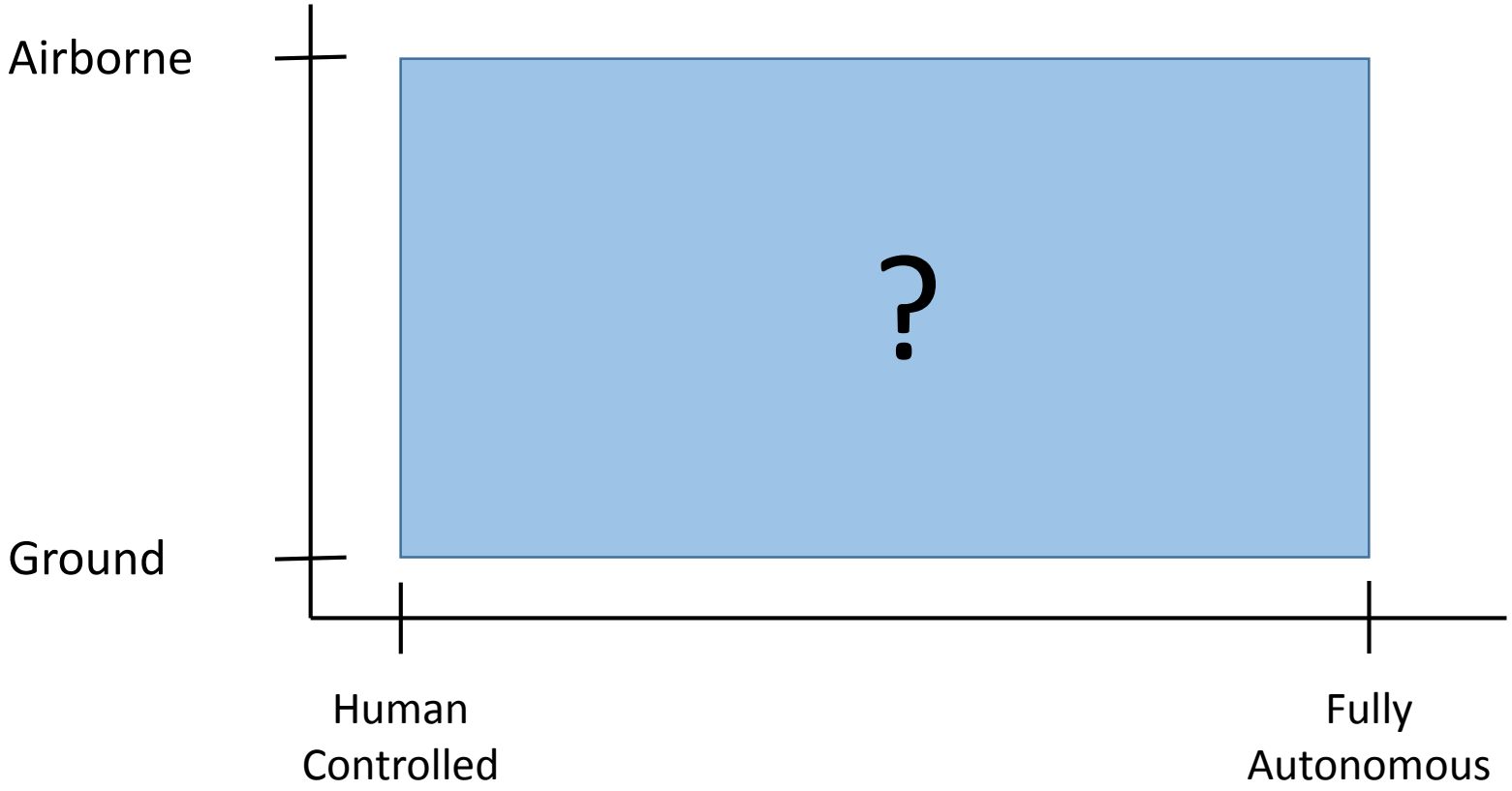
Air/Ground, Human/Automation Design Space



Breakdown of Single Concept of Operations



What is the problem?



Separation Assurance Function Allocation

Function Allocation: Of all the necessary functions comprising a Separation Assurance system, how and where should the functions be performed?

Current Research Goal: Make recommendations about the allocation of **en route** separation assurance functions in the future National Airspace System to humans/automation/ground-based/airborne agents

How does Function Allocation help?

- The design space is broken up into a series of key questions
  - 6 questions covering the air/ground performance studies
  - 4 questions covering the human/automation performance studies
- Each question addressed individually by a team of researchers
- Recommendations will be in the final roll-up

Function Allocation Questions

Airborne/Ground

- Surveillance, state information, intent quality effect on conflict detection
- Overall effect of level of coordination and information availability
- Level of coordination effect on arrival merging and spacing
- Distributing and layering Separation Assurance functions
- Effect of resource constraints on throughput
- Effect of weather information and function allocation on efficiency

Human/Automation

- Controller Separation Assurance functions in future National Airspace System
- Flight crew Separation Assurance functions in future National Airspace System
- Separation Assurance responsibility transfer between humans, pilots, and automation
- Explore human compensation options for imperfect automation in Separation Assurance

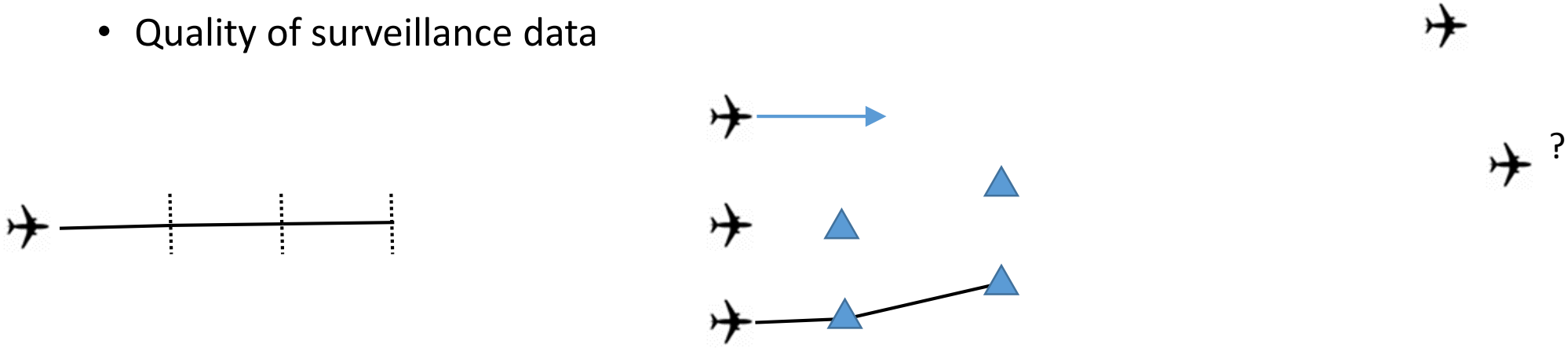
Overall System Level Challenges

- To make recommendations, a broad knowledge base is needed
  - Traditional studies that examine individual “point” concepts will not efficiently cover the test area
  - Identifying key variable interactions when comparing configurations is important and difficult
- Some variables are continuous, others are binary or have specific settings
  - Different analysis approaches needed to examine different types of variables
- Identifying meaningful results is more complicated
  - Individual study results will be focused on trends and identifying characteristics of different test configurations
  - Incomplete results or results that do not project to a larger system can make roll-up more difficult

Parametric Studies Example

How does surveillance, flight state information, and trajectory intent quality affect conflict detection performance?

- Conflict detection carried out by automation for this study
- Quality and content of input data expected to be primary cause of performance differences
  - Quantity of shared intent data
  - Quality of shared intent data
  - Quality of surveillance data



Parametric Studies Example

How does surveillance, flight state information, and trajectory intent quality affect conflict detection performance?

- Determine known variables based on system requirements or hardware limitations
  - Maximum missed detection rate
  - Surveillance range
  - Conflict detection cycle rate
  - Quality of intent data shared
- Results can be used to refine requirements, or zero in on ranges for testing for other variables
  - Conflict detection time horizon
  - Expected false alert rate

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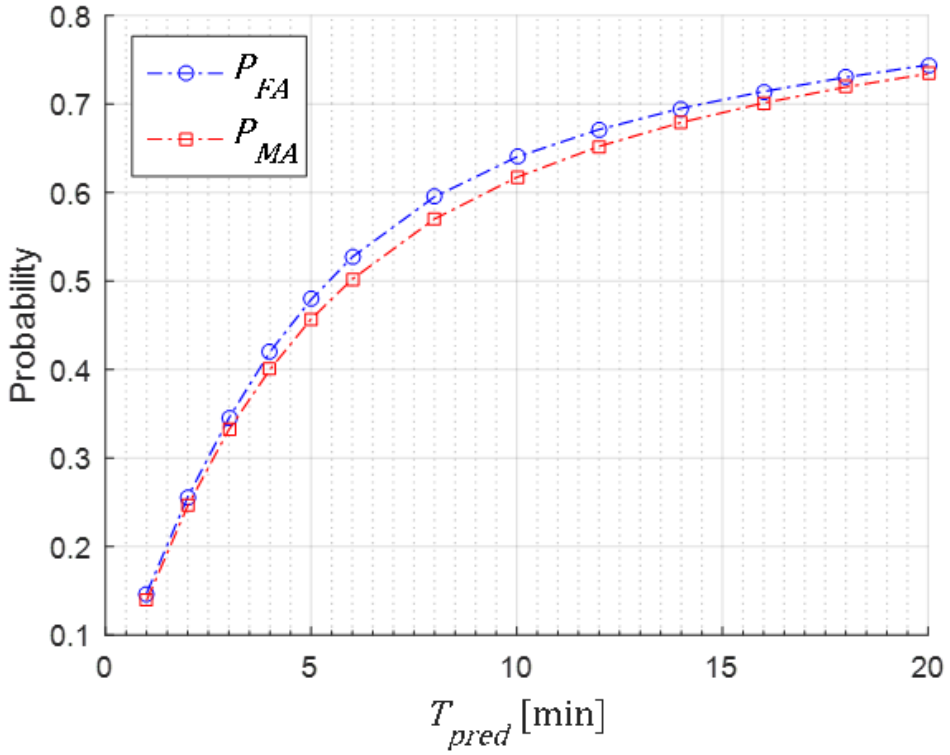


Non-Parametric Studies Example

What is the effect of the level of coordination during arrival merging and spacing on schedule conformance and stability?

- Conflict detection and resolution carried out by automation for this study
- Multiple variables have discrete settings
  - Location of scheduling algorithm
  - Location of agent responsible for managing arrivals
- Intended output will be characteristics of each configuration tested
  - Sensitivity to primary variables
  - Key contributors to performance differences

Non-Parametric Studies Example

What is the effect of the level of coordination during arrival merging and spacing on schedule conformance and stability?

- Looking for characteristics of:
  - Configuration – Caused by functional differences between concepts
  - Simulation – Caused by simulation framework
  - Algorithm – Caused by algorithm properties
- Traditional metrics (i.e. delay, number of maneuvers) should not be used for direct comparisons
  - “Fair” comparisons difficult
  - Goal of individual studies not to pick a best solution

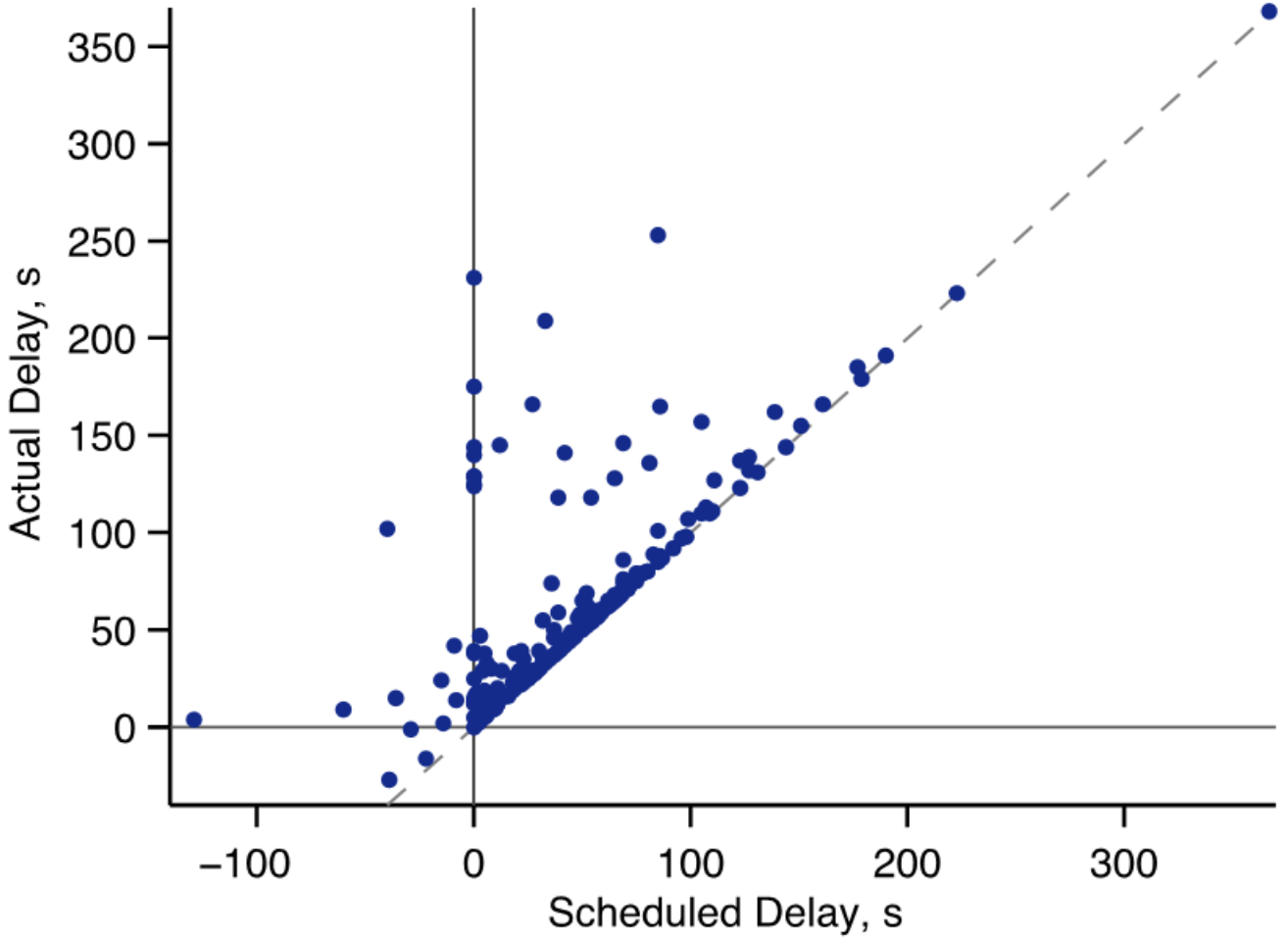
Breaking Down Comparison Metrics

	Concept A	Concept B
delay/maneuver	40	65

Δdelay = 25

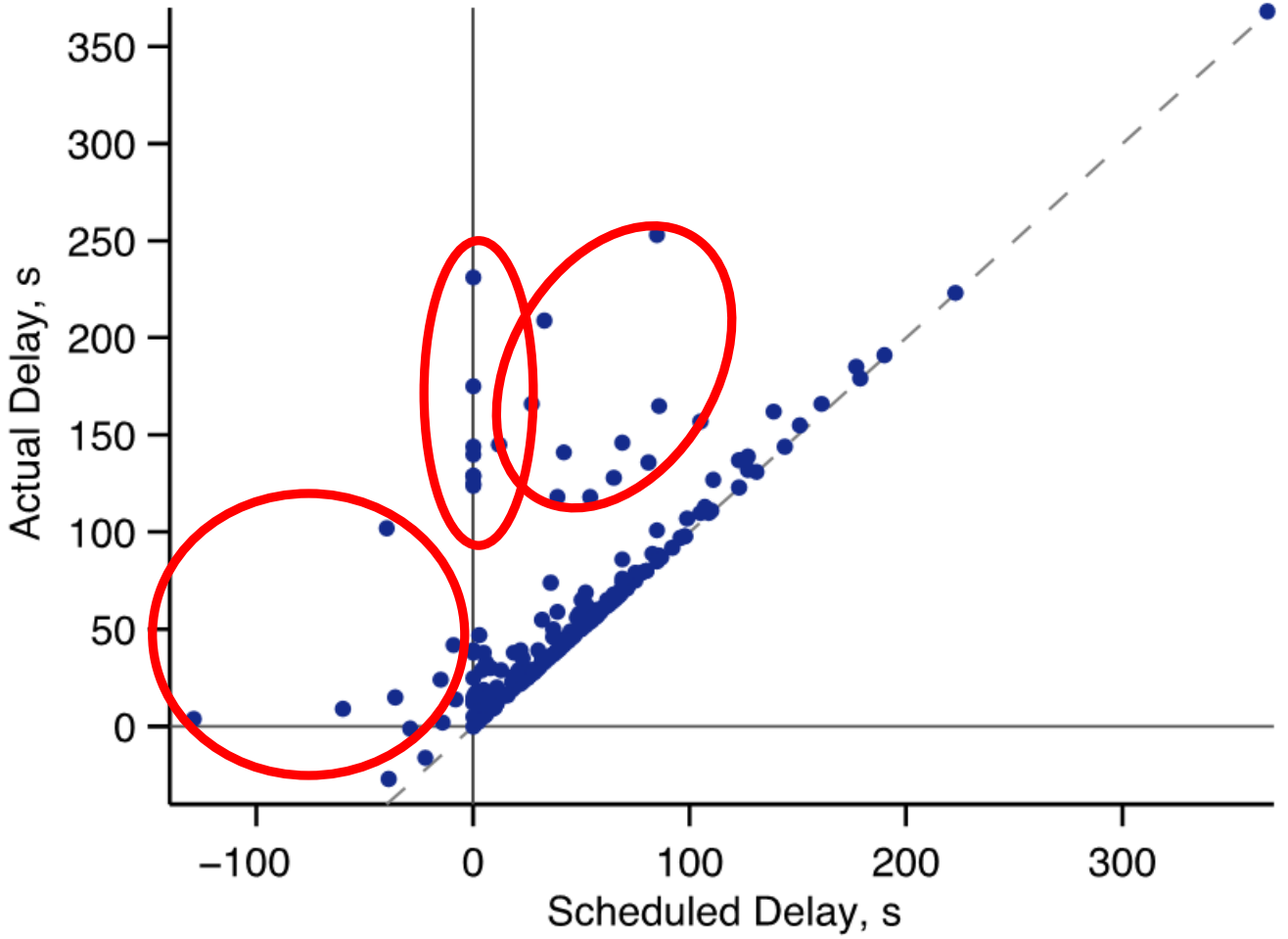
10 – Algorithm differences concept A vs B
8 – Simulation implementation concept A vs B
presence of remainder points to Functional differences between concept A vs B

Breaking Down A Single Metric



Identify root causes for key features of each metric

Breaking Down A Single Metric



Identify root causes for key features of each metric

Root causes related to algorithms may be addressable with code adjustments, while those related to the simulation may not be

Summary

- The goal of current Function Allocation research in Air Traffic Management is to explore the design space of a future Separation Assurance system and provide recommendations to decision makers
- Design space broken up into 10 questions: 6 related to the air/ground axis and 4 related to the human/automation axis
- Researchers need to separate characteristics of the configuration, simulation, and algorithms as much as possible
- Individual study outputs need to be presented in a way that can be rolled-up with results from other studies into a single reference